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<p>(21) International Application Number: <b>PCT/KR98/00009</b></p> <p>(22) International Filing Date: <b>19 January 1998 (19.01.98)</b></p> <p>(30) Priority Data: 1997/1360                    18 January 1997 (18.01.97)                    KR</p> <p>(71) Applicant (<i>for all designated States except US</i>): <b>BORYUNG PHARMACEUTICAL CO., LTD. [KR/KR]</b>; Boryung Building, 66-21, Wonnam-dong, Chongro-ku, Seoul 110-450 (KR).</p> <p>(71)(72) Applicant and Inventor: <b>CHUNG, Yong-Hoon [KR/KR]</b>; 405-804, Jukong Apt., Dunchon-dong, Kangdong-ku, Seoul 134-060 (KR).</p> <p>(74) Agent: <b>SUH, Jong, Wan</b>; New-Seoul Building, 3rd floor, 828-8, Yeoksam-dong, Kangnam-ku, Seoul 135-080 (KR).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b>  <i>With international search report.</i>  <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>	
<p>(54) Title: <b>A CTLA4-Ig FUSION PROTEIN HAVING HIGH TITER</b></p>			
<p>The diagram illustrates the structure of the Human CTLA4-Ig fusion protein. It features a leader sequence at the N-terminus, followed by an extracellular region containing the CTLA4 domain and the IgG1 domain. The IgG1 domain is composed of four hinge, CH<sub>2</sub>, and CH<sub>3</sub> regions. The diagram shows five different linkage points (L1 to L5) where the extracellular region is fused to the IgG1 domain. In L1, the fusion is at the hinge region. In L2, L3, and L4, it is at the CH<sub>2</sub> region. In L5, it is at the CH<sub>3</sub> region. The sequences shown for the extracellular region are:</p> <ul style="list-style-type: none"> <li>L1: <b>mACIGFQRHKIAQUNIAARTWPCTLLFLILIPVPCKA</b></li> <li>L2: <b>mKHIAQUNIAARTWPCTLLFLILIPVPCKA</b></li> <li>L3: <b>mQLUNIAARTWPCTLLFLILIPVPCKA</b></li> <li>L4: <b>mRTWPCTLLFLILIPVPCKA</b></li> <li>L5: <b>mLIFFLFLIPVPCKA</b></li> </ul>			
<p>(57) Abstract</p> <p>The present invention relates to a CTLA4-Ig fusion protein, in which an extracellular region of the CTLA4 is connected to CH<sub>2</sub>, CH<sub>3</sub>, and CH<sub>4</sub> of IgM or to hinge, CH<sub>2</sub> and CH<sub>3</sub> of IgG1 Cys308, and six monomers of which are polymerized to be a hexameric structure. According to the present invention, it is provided a CTLA4-Ig fusion protein having a decreased dosage and high titer.</p>			

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## A CTLA-4 Ig FUSION PROTEIN HAVING HIGH TITER

### Technical Field

The present invention relates to a CTLA4-Ig fusion protein having high titer, and more particularly, to a fusion protein connecting an extracellular region of CTLA4 and C $\mu$  of IgM or C $\gamma$  1 region of IgG.

### Background Art

In organ transplant, fatal to a patient is the rejection by immunoreaction which occurs by discriminating self and non-self.

In the rejection of the organ transplant, T-cell plays an important role. The reaction of T-cell starts with two kinds of signals, an antigen-sensitive stimulatory and a costimulatory signals. A large number of ligand/receptor bonds including ICAM-1/LFA-1, B7/CD28 and CTLA4 and LFA-3/CD2 participate in the costimulation. Especially, CD28 plays an important role in the reaction of the T-cell, making stable mRNA of a T-cell cytokinin by binding to the B7.1 and B7.2(June, C. H. *et al.*, *Mol. Cell Biol.*, 7, 4472, 1987/Lindstent, *et al.*, *Science*, 244, 339, 1989), and increasing the productivity of interleukin-2(IL-2), interferon- $\gamma$  (IFN- $\gamma$ ), tumor necrosis factor- $\alpha$  (TNF- $\alpha$ ), lymphotoxin, granulocyte macrophage-colony stimulating factor(GM-CSF), and interleukin-3(IL-3).

Thus if the costimulation by the CD28 is blocked by inhibiting binding of the CD28 and the B7.1 and B7.2, the rejection of the organ transplant can be suppressed.

CTLA4 has 67% homology with the CD28, binding to the B7(B7.1 and B7.2) of an antigen presenting cell(APC) like CD28. Linsley *et al.* reported that a monomeric CTLA4-Ig fusion protein was prepared by fusing the CTLA4 and an IgG, and that the protein has the immunosuppression effect (Linsley, P. S. *et al.*, *J. Exp. Med.* 174, 561, 1991). Yamada *et al.* recently reported that they manufactured a

pentameric CTLA4-IgM fusion protein and that the protein extended lives of patients after the organ transplant (Yamada, A. *et al.*, *Microbio. Immunol.*, **40**, 513~518, 1996)

However, the CTLA4-Ig fusion protein, since its too much dosage of 600 mg per once for a 60 kg adult and high manufacturing cost, is hardly commercially viable.

### **Disclosure of the Invention**

According to one aspect of the present invention, there is provided a CTLA4-Ig fusion protein in which an extracellular region is connected with CH<sub>2</sub>, CH<sub>3</sub>, and CH<sub>4</sub> region of IgM, or with a hinge, CH<sub>2</sub>, and CH<sub>3</sub> of IgG1 Cys<sub>308</sub>(IgG1 having Cys<sub>308</sub>), and which has a hexameric structure.

The hexameric structure of the CTLA4-Ig fusion protein is caused by forming multimer between adjoining IgMs or between IgG1 Cys<sub>308</sub>s forced by disulfide bonds of cysteins. To put it concretely, Cys<sub>414</sub> and Cys<sub>567</sub> of the IgM make a disulfide bond and, in case of IgG1 Cys<sub>308</sub>s of IgG1s make a disulfide bond. The IgG1 Cys<sub>308</sub> of the present invention is the one that Leu<sub>308</sub> of the IgG1 CH<sub>2</sub> region, the correspondent site of Cys<sub>414</sub> of IgM, is converted to cystein in order to form polymeric IgG1 like IgM.

According to another aspect of the present invention, there is provided DNA base sequence coding amino acid sequence correspondent to the CTLA4-Ig fusion protein.

According to still another aspect of the present invention, there is provided the expression vectors pHIGH3neo and pHIGHgpt manufactured by inserting to vectors of pSV2neo and pSV2gpt an enhancer, a promoter, CTLA4 leader sequence of which N-terminal is cut, and DNA sequence coding amino acid sequence correspondent to the CTLA4-Ig fusion protein. The CTLA4 leader sequence of which N-terminal is cut makes the CTLA-Ig fusion protein secreted to the outside of cell.

According to still another aspect to the present invention, there is provided a transformed body manufactured by inserting to a mouse SP2/0-Ag14 cell the expression vectors pHIGH3neo and pHIGH3gpt which is manufactured by inserting to the vectors pSV2neo and pSV2gpt 5 an enhancer, a promoter, CTAL4 leader sequence of which N-terminal is cut, and the DNA sequence coding amino acid sequence correspondent to the CTLA4-Ig fusion protein.

According to still another aspect of the present invention, there is provided an immunosuppressant containing the CTLA4-Ig fusion protein. 10 The CTLA4-Ig fusion protein of the present invention, a soluble protein, binds to the B7 of the antigen presenting cell to inhibit binding of the CTLA4 and the CD28 of T-cell at the B7, to block costimulatory signal needed for the activation of T-cell and, in the result, the immunoreaction is suppressed.

15 By the features of the present invention, the titer of the CTLA4-Ig fusion protein according to the present invention is 32~356 times of an existing CTLA4-Ig fusion protein. The dosage of the CTLA4-Ig fusion protein according to the present invention is 2~13 mg per once for a 60 kg adult, and it's effective titer is 45~260 times of the existing CTLA4-Ig 20 fusion protein's.

### Brief Description of the Drawings

The above objects, and other features and advantages of the present invention will become more apparent after a reading of the following 25 detailed description taken in conjunction with the drawings, in which:

Fig.1 is a structure of a CTLA4 gene cloned by a reverse transcription-polymerase chain reaction(RT-PCR) of example 1.

Fig.2 is a expression ratio of a fusion protein of example 2.

Fig. 3a, 3b are base sequences of a CTLA4-IgM fusion gene of 30 example 2 and an correspondent amino acid sequence thereof.

Fig. 4a, 4b are base sequence of a CTLA4-IgG1 Cys<sub>308</sub> fusion gene of example 3 and a correspondent amino acid sequence thereof.

Fig. 5a, 5b are a manufacturing method for the expression vectors of pHIGH3neo and pHIGH3gpt of the CTLA4-IgM fusion gene and the CTLA4-IgG1 Cys<sub>308</sub> fusion gene.

5 Fig. 6a, 6b are western blots of the CTLA4-IgM fusion protein and the CTLA4-IgG1 Cys<sub>308</sub> fusion protein.

Fig. 7 is a structure of 600kD of the CTLA4-IgM fusion protein or the CTLA4-IgG Cys<sub>308</sub> fusion protein.

10 Fig. 8 is a graph showing the immunosuppression effect of the CTLA4-IgM fusion protein and the CTLA4-IgG1 Cys<sub>308</sub> fusion protein.

### Best Mode for Carrying out the Invention

The present invention is further illustrated in the following example, which should not be taken to limit the scope of the invention.

15

#### Example 1: Cloning of human CTLA4, IgG1, and IgM genes

CTLA4, IgG1, and IgM genes were cloned respectively by the method of a reverse transcription-polymerase chain reaction(RT-PCR).

##### 1. Cloning of the CTLA4 gene

20 A template used for the cloning of the CTLA4 gene by the reverse transcription-polymerase chain reaction was mononucleocyte mRNA of a healthy adult. The mRNA was separated as follows:

25 Blood taken from a healthy adult was density-gradient centrifuged using Ficoll-Hypaque to obtain monocyte cell layer. By adding RPMI-1640 medium containing 10% bovine fetus to the above monocytes 5X10<sup>5</sup> monocytes/ml was made and here leukoagglutinin(Pharmacia Corp.) added to be 3.5 µg/ml. The mixture was incubated 36~48 hours under the condition of 5% CO<sub>2</sub>, 37°C in order to separate mRNA.

30 The polymerase used in the reverse transcription-polymerase chain reaction was pfu(Stratagene Corp.).

The primers used in the reverse transcription-polymerase chain

reaction are five forward primers(L1~5) and a reverseward primer, as follows;

Forward primers

- 5           L1    5'-ATG GCT TGC CTT GGA TTT CAG-3'  
L2    5'-ATG CGG CAC AAG GCT CAG CTG AAC-3'  
L3    5'-ATG CAG CTG AAC CTG GCT GCC AGG-3'  
L4    5'-ATG AGG ACC TGG CCC TGC ACT CTC-3'  
L5    5'-ATG CTC CTG TTT TTT CTT CTC TTC-3'

Revereward primer

- 10           5'-CTC TGC AGA ATC TGG GCA CGG TTC AGG ATC-3'

It is invented for the L1 primer to be expressed as an original CTLA4 without cutting, for the L2 primer as a form that 6 amino acids of it were cut from N-terminal, 11 amino acids cut for the L3, 16 amino acids cut for the L4, and 22 amino acids cut for the L5 from N-terminal (Fig.1).

Inventing the forward primers to be expressed as cutting form of amino acids from N-terminal is for a part of leader sequence to be cut and expressed , and for the CTLA4 protein to be secreted to an extracellular region. And 5 primers were invented in order that the leader sequence is cut and expressed one by one for the determination of a leader sequence which makes the most CTLA4 proteins secreted to extracellular region.

20           CTLA4 gene obtained by the reverse transcription-polymerase reaction was cloned to pUC 18. The cloned CTLA4 gene has confirmed which base No.49 was converted from adenine to guanine, and base No.331 was converted from guanine to adenine. In the result, an amino acid No.17 of CTLA4 protein was converted from threonine to alanine, and an amino acid No.111 of CTLA4 protein was converted from alanine to threonine.

## 2. Cloning of IgG1 gene

The cloning method was same with the method of the above 1 of the example 1 except template and primer. The template used here was mRNA of B-cell at peripheral blood lymph node obtained from a recovering ill-defined fever patient. The primer was invented in order to clone a counterbalancing of IgG1 as follows;

5           Forward primer  
          5'-A TCT GCA GAG CCC AAA TCT TGT GAC-3'  
          Reverseward primer  
10          5'-TT CTC GAG TCA TTT ACC CGG AGA CAG GGA-3'

## 3. Cloning of IgM gene

Same with the method of the above 2 of the example 1 except primer. The primer was invented in order to clone a counterbalancing of 15 the IgM as follows;

15          Forward primer  
          5'-GAC TGC AGA GCT GCC TCC CAA AGT G-3'  
          Reverseward primer  
20          5'-GTA GCA GGT GCC AGC TGT GTC TGA-3'

### **Example 2: Determination of the optimum leader sequence for extracellular secretion**

The five CTLA4 genes obtained by serial deletion of N-terminal amino acids were fused with IgG1 respectively, inserted to a vector pHIGH3, and transfected to a mouse bone marrow SP2/0-Ag14 cell(ATCC#: CRL 1581) to be expressed. And after an incubation for 48 hours, the expression ratio was analyzed by a cell circulation assay.

The result of the above analysis shows that in case of L1 primer 4.9% of the fusion protein, 3.1% for L2 primer, 0% for L3 primer, 7.8% for L4 primer and 6% for L5 primer are expressed (Fig.2). It confirms that the leader sequence deleted of 16 amino acids from N-terminal, obtained by using L-4 primer, makes the most fusion proteins secreted

most to an extracellular region.

**Example 3: Manufacturing of IgG1 Cys<sub>308</sub>**

IgG1 Cys<sub>308</sub> was manufactured by converting Leu<sub>308</sub> of IgG1 to cysteine using a polymerase chain reaction. The primers used in the polymerase chain reaction are as follows;

Forward primer

5'-A TCT GCA GAG CCC AAA TCT TGT GAC-3'

10 Reverseward primer

5'-TT CTC GAG TCA TTT ACC CGG AGA CAG GGA-3'

Converting primer

5'-CCA GTC CTG GTG ACA GAC GGT GAG GAC-3'

15 First, the primary polymerase chain reaction using the forward primer and reverseward primer was performed, and then using the product of the above reaction and reverseward primer, secondary polymerase chain reaction was performed. The amplified product of the secondary polymerase chain reaction was cloned in pUC18 vector.

20

**Example 4: Construction of the expression vector of the CTLA4-Ig fusion gene**

25 Genome DNA of SP2/0-Ag14 cell was extracted, cut with restriction enzymes of BamH I and Hind III, transferred to a nitrocellulose membrane, and performed Southern blot with 5'-ATT TGC ATA TTT GCA TAT TTG CAT-3' fragment and 5'-CTC ATG ACT CAT GAC TCA-3' fragment marked with isotope to clone 5.3kb promoter.

30 On the other hand genome DNA of SP2/0-Ag14 cell was cut by restriction enzymes of EcoR I and BamH I and performed the southern blot with 5'-TGA ATT GAG CAA TGT TGA ATT GAG CAA TGT-3' fragment and 5'-TAT TTG GGG AAG GGT ATT TGG GGA AGG-3' fragment marked with isotope to clone 1kb enhancer.

**An enhancer-promoter-CTLA4-**

Ig fusion gene was cloned to pUC 18 by fusing the 1kb enhancer and 5.3 kb promoter in pUC 19, and inserting the fused product to the site of Sal I, the front part of CTLA4-

- 5 Ig fusion gene cloned in pUC 18(CTLA4-IgM fusion gene of the example 2 and CTLA4-IgG1 Cys<sub>308</sub> fusion gene of the example 3, Fig.3a,3b and Fig.4a, 4b). By cutting only enhancer-promoter-CTLA4-Ig fusion gene by treating EcoR I and Hind III to the above clone  
10 and then by inserting the clone to pSV2neo and pSV2gpt, the expression vectors of pHIGH3neo and pHIGH3gpt was constructed (Fig. 5a, 5b).

15 **Example 5: Expression of CTLA4-Ig fusion gene and purification of  
CTLA4-Ig fusion protein**

SP2/0-Ag14 cell of mouse was incubated in 10% FCS-DMEM medium, and diluted to 5X10<sup>6</sup> cells/ml by adding PBS. The above suspension 0.2ml was put to cuvette(BioRad Corp.) for electroporation and the purified expression vector 15μg of the CTLA4-Ig fusion gene of example 4 was added. And then electroporation (BT×820) was performed under the condition of 480V, 99 μsec, 2cycle.

The above cells were incubated for 3 weeks in the FCS-DMEM medium containing 1500μg/ml of geneticin G418(Gibco Corp.). And then colonies were separated, collected, and incubated for amplifying.  
25 The CTLA4-Ig fusion gene expression was examined by the a cell circulation analyzer and enzyme linked immunosorbent assay(ELISA) method.

These cells were incubated in large quantities in FCS-medium and the CTLA4-Ig fusion protein was precipitated by ammonium sulfate addition. And then by an affinity chromatography using protein A, the  
30 CTLA4-Ig fusion protein was purified.

In order to fine out the biochemical properties of the CTLA4-Ig fusion protein, electrophoresis and western blot were performed(F

ig. 6a, 6b). The result shows that there are two kinds of the CTLA4-IgM fusion protein and six kinds of the CTLA4-IgG1 fusion protein. Among these, CTLA4-Ig fusion protein of 600kD was separated and purified. The CTLA4-Ig fusion protein of 600kD is 6 times as large as the existing CTLA4-Ig fusion protein(100kD), and is a hexamer which was six of CTLA4-Ig fusion protein polymerized (Fig.7).

10

#### **Example 6: Immunosuppression effect of the CTLA4-Ig fusion protein**

15

The existing CTLA4-Ig fusion protein is a comparative example 1, the pentameric CTLA4-Ig fusion protein is a comparative example 2, and the hexameric CTLA4-Ig fusion protein is an example. and the Immunosuppression effects of them were examined as follows;

From two healthy adults peripheral blood lymphocytes were separated, and on the cells of the one person 300 rad of  $^{60}\text{Co}$  radiation was irradiated.

20

The cells of the two persons were spread into a 96-well plate with  $2.5 \times 10^4$  cells/ml, respectively. And after incubating for 88~96 hours under the condition of  $37^\circ\text{C}$ , 5%  $\text{CO}_2$ , added  $0.5 \mu\text{Ci} \ ^3\text{H}$ -thymidine(NEN Research product) per well and incubated 5 hours again.

25  
30

The incubated cells were adsorbed to a glass filter by using titertek(Flow lab), put into a test tube, and after adding  $5\mu\text{l}$  of Scintillation cocktail a radioactivity was measured by using  $\beta$ -liquid scintillation counter. The all tests were performed three for every times under the same condition and an average of them was determined. The percent value gained by adding the fusion protein of the present invention was calculated on the basis of the radiation value(100%) gained without an addition. And when the value reaches to 50%, the value was defined as a line of 50% division suppression and the titer between fusion proteins was compared on the basis of the concentration of the adding

fusion protein.

As a result, the 50% division suppression concentration of the CTLA4-Ig fusion protein of this example is 0.009~0.022  $\mu\text{g}/\text{ml}$ (the average is 0.016  $\mu\text{g}/\text{ml}$ ). This value is lower than 0.7~3.2  $\mu\text{g}/\text{ml}$ (the average is 1.4  $\mu\text{g}/\text{ml}$ ) of the comparative example 1 and lower than 0.031~0.056  $\mu\text{g}/\text{ml}$  (the average is 0.44  $\mu\text{g}/\text{ml}$ ) the comparative example 2 (Fig.8). CTLA4-Ig fusion protein of this example has high titer, 32~356 times (the average is 88 times) comparing to the existing CTLA4-Ig fusion protein of the comparative example 1 .

## CLAIMS

1. A CTLA4-IgM fusion protein, wherein an extracellular region of a CTLA4 is connected with CH<sub>2</sub>, CH<sub>3</sub>, and CH<sub>4</sub> of IgM, and which has a hexameric structure by polymerization of 6 monomers thereof.
- 5 2. A DNA sequence of Fig.4a, 4b coding the amino acid sequence corresponding to the CTLA4-IgM fusion protein as claimed in Claim 1.
- 10 3. An expression vector pHIGH3neo which is constructed by connecting an enhancer, a promoter and a CTLA4 of which N-terminal is cut, and DNA sequence coding amino acid sequence correspondent to the CTLA4-IgM fusion protein of Claim 1, and then by inserting the DNA sequence into vector pSV2neo.
- 15 4. An expression vector pHIGH3neo as claimed in Claim 3, wherein 16 amino acids of a leader sequence are cut from N-terminal.
- 20 5. A transformed body manufactured by inserting to a mouse SP2/0-Ag14 the expression vector pHIGH3neo constructed by connecting an enhancer, a promoter and a CTLA4 of which N-terminal is cut, and DNA sequences coding amino acid sequence correspondent to the CTLA4-IgM fusion protein of Claim 1, and then by inserting them into vector pSV2neo.
6. An immunosuppression medicine containing the CTLA4-IgM fusion protein in Claim 1.
- 25 7. A CTLA4-IgG1 Cys<sub>308</sub> fusion protein, wherein the extracellular region of CTLA4 is connected with a hinge, CH<sub>2</sub> and CH<sub>3</sub> of the IgG1 Cys<sub>308</sub> (IgG1 having Cys<sub>308</sub>) and which has a hexameric structure by polymerization of 6 fusion protein monomers thereof.
8. A DNA sequence of Fig.3a, 3b coding amino acid sequence correspondent to the CTLA4-IgG1 Cys<sub>308</sub> fusion protein in Claim 7.
- 30 9. An expression vector pHIGH3neo which is constructed by connecting an enhancer, a promoter, and CTLA4 of which N-terminal is cut, and DNA sequence coding amino acid sequences correspondent to the CTLA4-IgG1 Cys<sub>308</sub> fusion protein in Claim 7, and then by inserting

them into a vector pSV2neo.

10. An expression vector pHIGH3neo as claimed in Claim 9, which  
16 amino acids of a leader sequence are cut from N-terminal.
11. A transformed body which is manufactured by inserting to a  
5 mouse SP2/0-Ag14 cell the expression vector pHIGH3neo constructed by  
connecting an enhancer, a promoter, and CTLA4 of which N-terminal is  
cut, and DNA sequence coding amino acid sequences correspondent to  
the CTLA4-IgG1 Cys<sub>308</sub> fusion protein in Claim 7, and then by inserting  
them into a vector pSV2neo.
- 10 12. An immunosuppressant containing the CTLA4-IgG1 Cys<sub>308</sub>  
fusion pr otein in Claim 7.

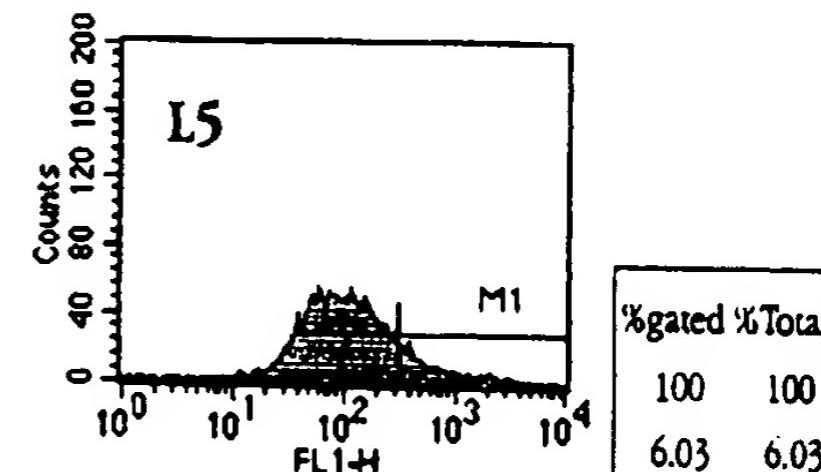
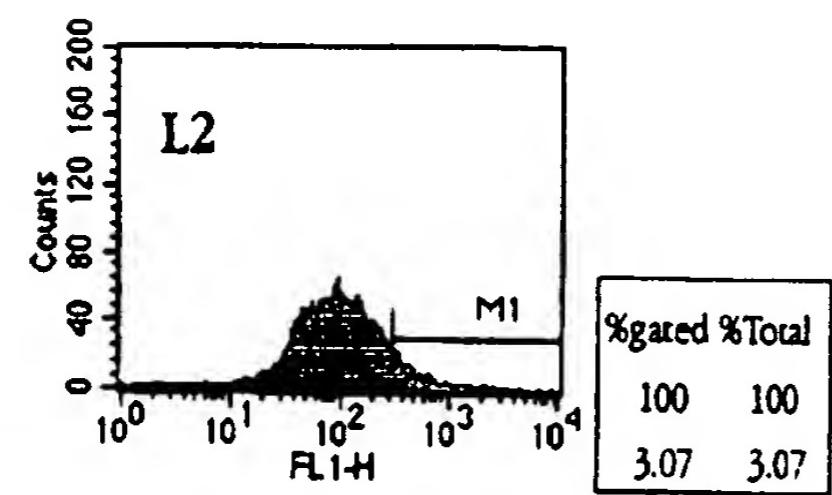
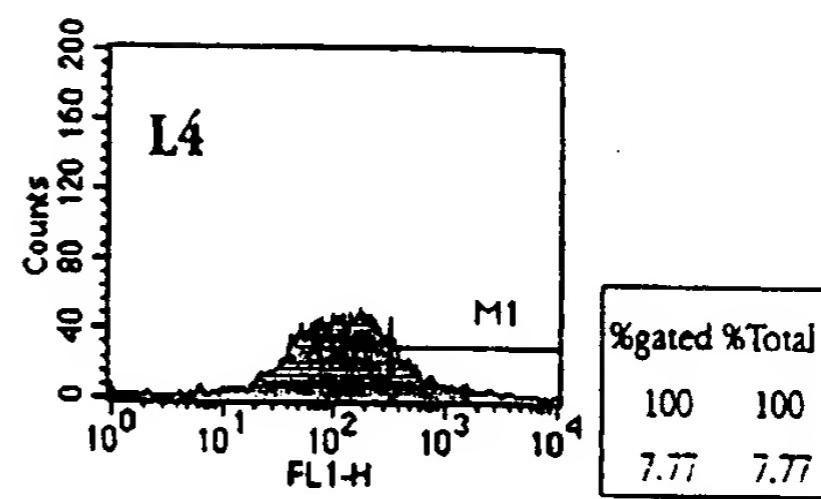
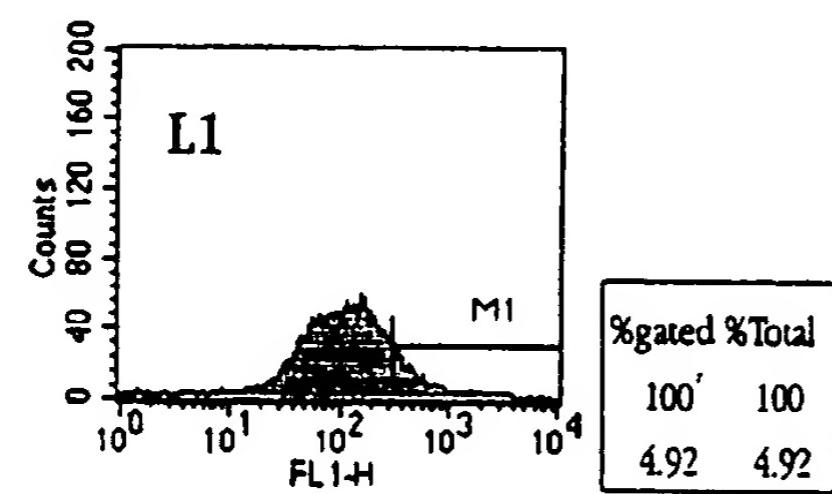
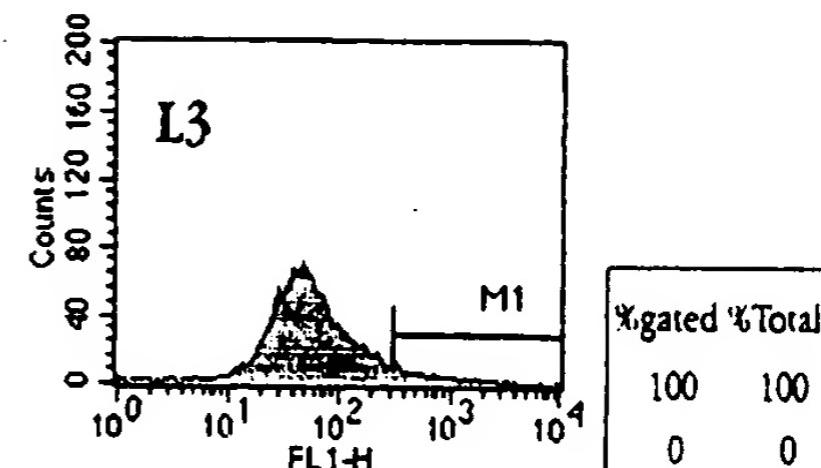
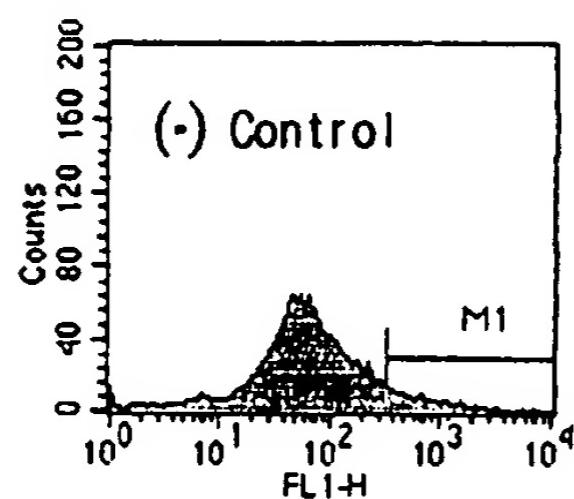
1/12

Fig. 1

	Human CTLA4	Human Immunoglobulin
	Leader Sequence	Extracellular region
L1	mACIGFQRHKAQQLNLAARTWPCTILLFFLIFIPVFCKA	CTLA4 IgG <sub>1</sub>
L2	mRHKAQQLNLAARTWPCTILLFFLIFIPVFCKA	CTLA4 IgG <sub>1</sub>
L3	mQLNLAARTWPCTILLFFLIFIPVFCKA	CTLA4 IgG <sub>1</sub>
L4	mRTWPCTILLFFLIFIPVFCKA	CTLA4 IgG <sub>1</sub>
L5	mLLFFLIFIPVFCKA	CTLA4 IgG <sub>1</sub>

2/12

Fig. 2



3/12

Fig. 3a

A	M	H	V	A	Q	P	A	V	V
GCA	ATG	CAC	GTG	GCC	CAG	CCT	GCT	GTG	GTA
L	A	S	S	R	G	I	A	S	F
CTG	GCC	AGC	AGC	CGA	GGC	ATC	GCC	AGC	TTT
V	C	E	Y	A	S	P	G	K	A
GTG	TGT	GAG	TAT	GCA	TCT	CCA	GGC	AAA	GCC
T	E	V	R	V	T	V	L	R	Q
ACT	GAG	GTC	CGG	GTG	ACA	GTG	CTT	CGG	CAG
A	D	S	Q	V	T	E	V	C	A
GCT	GAC	AGC	CAG	GTG	ACT	GAA	GTC	TGT	GCG
A	T	Y	M	M	G	N	E	L	T
GCA	ACC	TAC	ATG	ATG	GGG	AAT	GAG	TTG	ACC
F	L	D	D	S	I	C	T	G	T
TTC	CTA	GAT	GAT	TCC	ATC	TGC	ACG	GGC	ACC
S	S	G	N	Q	V	N	L	T	I
TCC	AGT	GGA	AAT	CAA	GTG	AAC	CTC	ACT	ATC
Q	G	L	R	A	M	D	T	G	L
CAA	GGA	CTG	AGG	GCC	ATG	GAC	ACG	GGA	CTC
Y	I	C	K	V	E	L	M	Y	P
TAC	ATC	TGC	AAG	GTG	GAG	CTC	ATG	TAC	CCA
P	P	Y	Y	L	G	I	G	N	G
CCG	CCA	TAC	TAC	CTG	GGC	ATA	GGC	AAC	GGA
T	Q	I	Y	V	I	D	P	E	P
ACC	CAG	ATT	TAT	GTA	ATT	GAT	CCA	GAA	CCG
C	P	D	S	A	E	P	K	S	C
TGC	CCA	GAT	TCT	GCA	GAG	CCC	AAA	TCT	TGT
D	K	T	H	T	C	P	P	C	P
GAC	AAA	ACT	CAC	ACA	TGC	CCA	CCG	TGC	CCA
A	P	E	L	L	G	G	P	S	V
GCA	CCT	GAA	CTC	CTG	GGG	GGG	CCG	TCA	GTC
F	L	F	P	P	K	P	K	D	T
TTC	CTC	TTC	CCC	CCA	AAA	CCC	AAG	GAC	ACC
L	M	I	S	R	T	P	E	V	T
CTC	ATG	ATC	TCC	CGG	ACC	CCT	GAG	GTC	ACA

CTLA-4

Extracellular  
regionHinge  
region

4/12

Fig. 3b

C	V	V	V	D	V	S	H	E	D
TGC	GTG	GTG	GTG	GAC	GTG	AGC	CAC	GAA	GAC
P	E	V	K	F	N	W	Y	V	D
CCT	GAG	GTC	AAG	TTC	AAC	TGG	TAC	GTG	GAC
G	V	E	V	H	N	A	K	T	K
GGC	GTG	GAG	GTG	CAT	AAT	GCC	AAG	ACA	AAG
P	R	E	E	Q	Y	N	S	T	Y
CCG	CGG	GAG	GAG	CAG	TAC	AAC	AGC	ACG	TAC
R	V	V	S	V	L	T	V	C	H
CGG	GTG	GTC	AGC	GTC	CTC	ACC	GTC	TGT	CAC
Q	D	W	L	N	G	K	E	Y	K
CAG	GAC	TGG	CTG	AAT	GGC	AAG	GAG	TAC	AAG
C	K	V	S	N	K	A	L	P	A
TGC	AAG	GTC	TCC	AAC	AAA	GCC	CTC	CCA	GCC
P	I	E	K	T	I	S	K	A	K
CCC	ATC	GAG	AAA	ACC	ATC	TCC	AAA	GCC	AAA
G	Q	P	R	E	P	Q	V	Y	T
GGG	CAG	CCC	CGA	GAA	CCA	CAG	GTG	TAC	ACC
L	P	P	S	R	D	E	L	T	K
CTG	CCC	CCA	TCC	CGG	GAT	GAG	CTG	ACC	AAG
N	Q	V	S	L	T	C	L	V	K
AAC	CAG	GTC	AGC	CTG	ACC	TGC	CTG	GTC	AAA
G	F	Y	P	S	D	I	A	V	E
GGC	TTC	TAT	CCC	AGC	GAC	ATC	GCC	GTG	GAG
W	E	S	N	G	Q	P	E	N	N
TGG	GAG	AGC	AAT	GGG	CAG	CCG	GAG	AAC	AAC
Y	K	T	T	P	P	V	L	D	S
TAC	AAG	ACC	ACG	CCT	CCC	GTG	CTG	GAC	TCC
D	G	S	S	F	L	Y	S	K	L
GAC	GGC	TCC	TCC	TTC	CTC	TAC	AGC	AAG	CTC
T	V	D	K	S	R	W	Q	Q	G
ACC	GTG	GAC	AAG	AGC	AGG	TGG	CAG	CAG	GGG
N	V	F	S	C	S	V	M	H	E
AAC	GTC	TTC	TCA	TGC	TCC	GTG	ATG	CAT	GAG
A	L	H	N	H	Y	T	Q	K	S
GCT	CTG	CAC	AAC	CAC	TAC	ACG	CAG	AAG	AGC
L	S	L	S	P	G	K			
CTC	TCC	CTG	TCT	CCG	GGT	AAA	TGA		

 $\text{CH}_2$  regionIgG<sub>1</sub>-Cys<sub>308</sub> $\text{CH}_3$  region

5/12

Fig. 4a

A	H	S	V	A	O	P	A	V	V
GCA	ATG	CAC	GTG	GCC	CAG	CCT	GCT	GTG	GTA
L	A	S	S	R	G	I	A	S	F
CTG	GCC	AGC	AGC	CGA	GGC	ATC	GCC	AGC	TTT
V	C	E	Y	A	S	P	G	K	A
GTG	TGT	GAG	TAT	GCA	TCT	CCA	GGC	AAA	GCC
T	E	V	R	V	T	V	L	R	Q
ACT	GAG	GTC	CGG	GTG	ACA	GTG	CTT	CGG	CAG
A	D	S	Q	V	T	E	V	C	A
GCT	GAC	AGC	CAG	GTG	ACT	GAA	GTC	TGT	GCG
A	T	Y	M	M	G	N	E	L	T
GCA	ACC	TAC	ATG	ATG	GGG	AAT	GAG	TTG	ACC
F	L	D	D	S	I	C	T	G	T
TTC	CTA	GAT	GAT	TCC	ATC	TGC	ACG	GGC	ACC
S	S	G	N	Q	V	N	L	T	I
TCC	AGT	GGA	AAT	CAA	GTG	AAC	CTC	ACT	ATC
Q	G	L	R	A	M	D	T	G	L
CAA	GGA	CTG	AGG	GCC	ATG	GAC	ACG	GGA	CTC
Y	I	C	K	V	E	L	M	Y	P
TAC	ATC	TGC	AAG	GTG	GAG	CTC	ATG	TAC	CCA
P	Y	Y	L	G	I	G	N	G	
CCG	CCA	TAC	TAC	CTG	GGC	ATA	GGC	AAC	GGA
T	Q	I	Y	V	I	D	P	E	P
ACC	CAG	ATT	TAT	GTA	ATT	GAT	CCA	GAA	CCG
C	P	D	S	A	E	L	P	?K	
TGC	CCA	GAT	TCT	GCA	GAG	CTG	CCT	CCC	AAA
V	S	V	F	V	P	P	R	D	G
GTG	AGC	GTC	TTC	GTC	CCA	CCC	CGC	GAC	GGC
F	G	N	P	R	K	S	K	L	
TTC	TTC	GGC	AAC	CCC	CGC	AAG	TCC	AAG	CTC
C	C	Q	A	T	G	F	S	P	R
ATC	TGC	CAG	GCC	ACG	GGT	TTC	AGT	CCC	CGG
Q	I	Q	V	S	W	L	R	E	G
CAG	ATT	CAG	GTG	TCC	TGG	CTG	CGC	GAG	GGG
K	Q	V	G	S	G	V	T	T	D
AAG	CAG	GTG	GGG	TCT	GGC	GTC	ACC	ACG	GAC
Q	V	Q	A	E	A	K	E	S	G
CAG	GTG	CAG	GCT	GAG	GCC	AAA	GAG	TCT	GGG
P	T	T	Y	K	V	T	S	T	L
CCC	ACG	ACC	TAC	AAG	GTG	ACC	AGC	ACA	CTG
I	K	E	S	D	W	L	G	O	
ACC	ATC	AAA	GAG	AGC	GAC	TGG	CTC	GGC	CAG
S	M	F	T	C	R	V	D	H	R
AGC	ATG	TTC	ACC	TGC	CGC	GTG	GAT	CAC	AGG
G	L	F	F	G	Q	N	A	S	S
GGC	CTG	ACC	TTC	CAG	CAG	AAT	GCG	TCC	TCC
M	C	V	P	J	Q	D	T	A	I
ATG	TGT	GTC	CCC	GAT	CAA	GAC	ACA	GCC	ATC
R	V	F	A	I	P	P	S	F	A
CGG	GTC	TTC	GCC	ATC	CCC	CCA	TCC	TTT	GCC

CTLA-4

Extracellular  
regionCH<sub>2</sub> region

6/12

Fig. 4b

S	I	F	L	T	K	S	T	K	L
AGC	ATC	TTC	CTC	ACC	AAG	TCC	ACC	AAG	TTG
C	L	V	T	D	L	T	T	Y	
ACC	TGC	CTG	GTC	ACA	GAC	CTG	ACC	ACC	TAT
D	S	V	T	I	S	W	T	R	Q
GAC	AGC	GTG	ACC	ATC	TCC	TGG	ACC	CGC	CAG
N	G	E	A	V	K	T	H	T	N
AAT	GGC	GAA	GCT	GTG	AAA	ACC	CAC	ACC	AAC
I	S	E	S	H	P	N	A	T	F
ATC	TCC	GAG	AGC	CAC	CCC	AAT	GCC	ACT	TTC
S	A	V	G	E	A	S	I	C	E
AGC	GCC	GTG	GGT	GAG	GCC	AGC	ATC	TGC	GAG
D	D	W	N	S	G	E	R	F	T
GAT	GAC	TGG	AAT	TCC	GGG	GAG	AGG	TTC	ACG
C	T	V	T	H	T	D	L	P	S
TGC	ACC	GTG	ACC	CAC	ACA	GAC	CTG	CCC	TCG
P	L	K	Q	T	I	S	R	P	K
CCA	CTG	AAG	CAG	ACC	ATC	TCC	CGG	CCC	AAG
G	V	A	L	H	R	P	D	V	Y
GGG	GTG	GCC	CTG	CAC	AGG	CCC	GAT	GTC	TAC
L	L	P	P	A	R	E	Q	L	N
TTG	CTG	CCA	CCA	GCC	CGG	GAG	CAG	CTG	AAC
L	R	E	S	A	T	I	T	C	L
CTG	CGG	GAG	TCG	GCC	ACC	ATC	ACG	TGC	CTG
V	T	G	F	S	P	A	D	V	F
GTG	ACG	GGC	TTC	TCT	CCC	GCG	GAC	GTC	TTC
V	Q	W	M	Q	R	G	Q	P	L
GTG	CAG	TGG	ATG	CAG	AGG	GGG	CAG	CCC	TTG
S	P	E	K	Y	V	T	S	A	P
TCC	CCG	GAG	AAG	TAT	GTG	ACC	AGC	GCC	CCA
M	P	E	P	Q	A	P	G	R	Y
ATG	CCT	GAG	CCC	CAG	GCC	CCA	GGC	CGG	TAC
F	A	H	S	I	L	T	V	S	E
TTC	GCC	CAC	AGC	ATC	CTG	ACC	GTG	TCC	GAA
E	E	W	N	T	G	E	T	Y	T
GAG	GAA	TGG	AAC	ACG	GGG	GAG	ACC	TAC	ACC
C	V	A	B	E	A	L	P	N	R
TGC	GTG	GCC	CAT	GAG	GCC	CTG	CCC	AAC	AGG
V	T	E	R	T	V	D	K	S	T
GTC	ACC	GAG	AGG	ACC	GTG	GAC	AAG	TCC	ACC
G	K	P	T	L	Y	N	V	S	L
GGT	AAA	CCC	ACC	CTG	TAC	AAC	GTG	TCC	CTG
V	M	S	D	T	A	G	T	C	Y
GTC	ATG	TCC	GAC	ACA	GCT	GGC	ACC	TGC	TAC
	TGA								

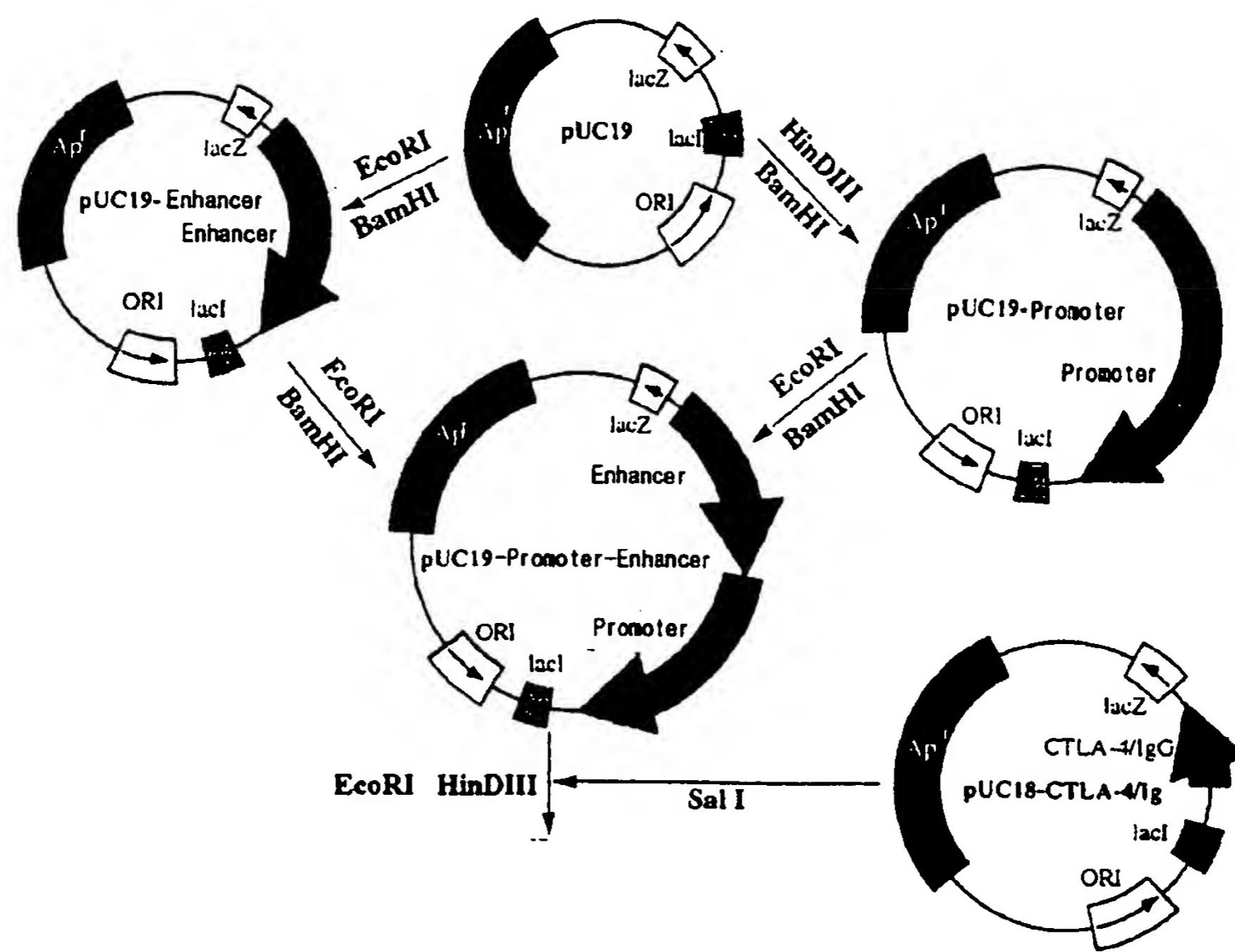
 $\text{CH}_3$  region

IgM

 $\text{CH}_4$  region

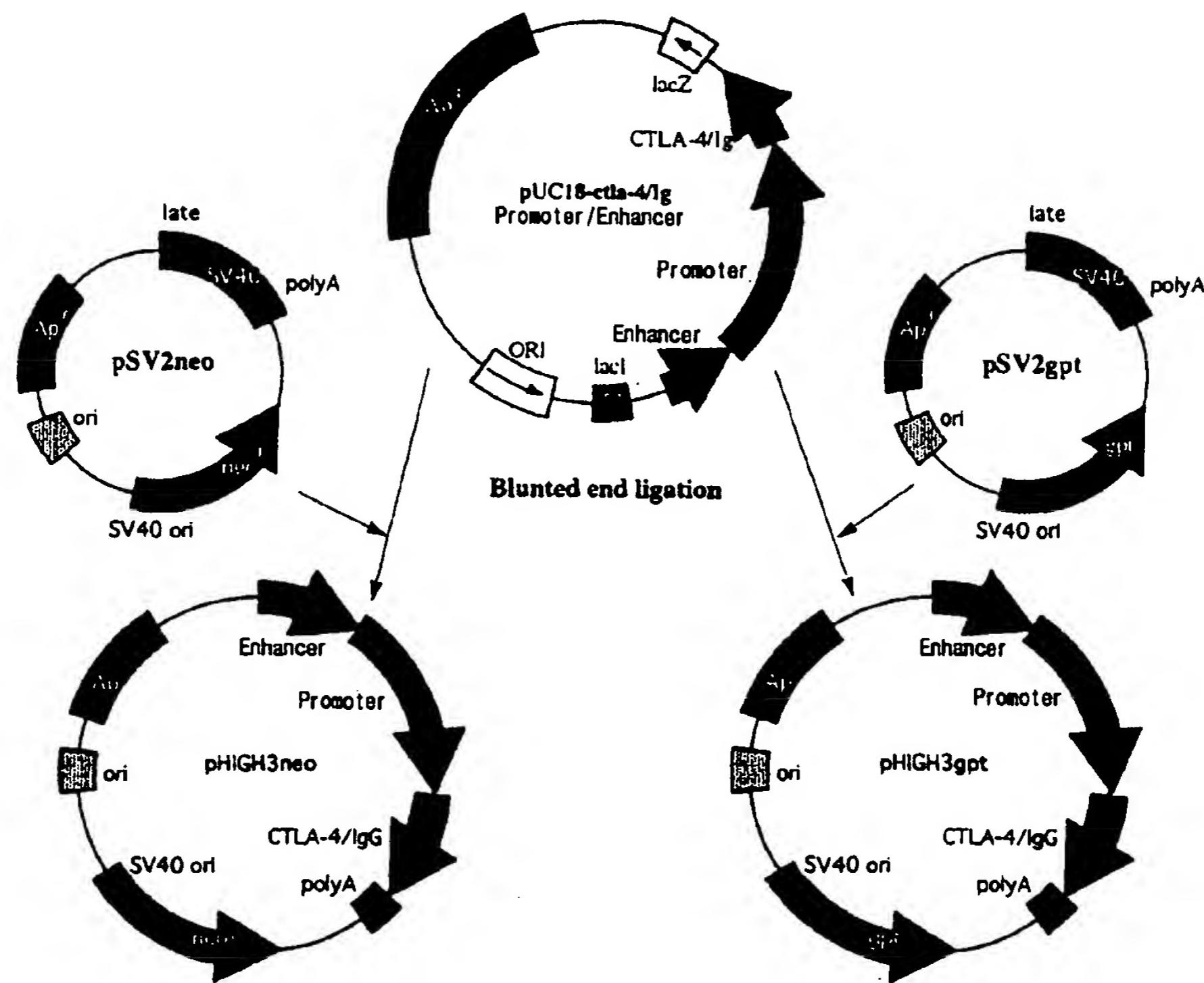
7/12

Fig. 5a



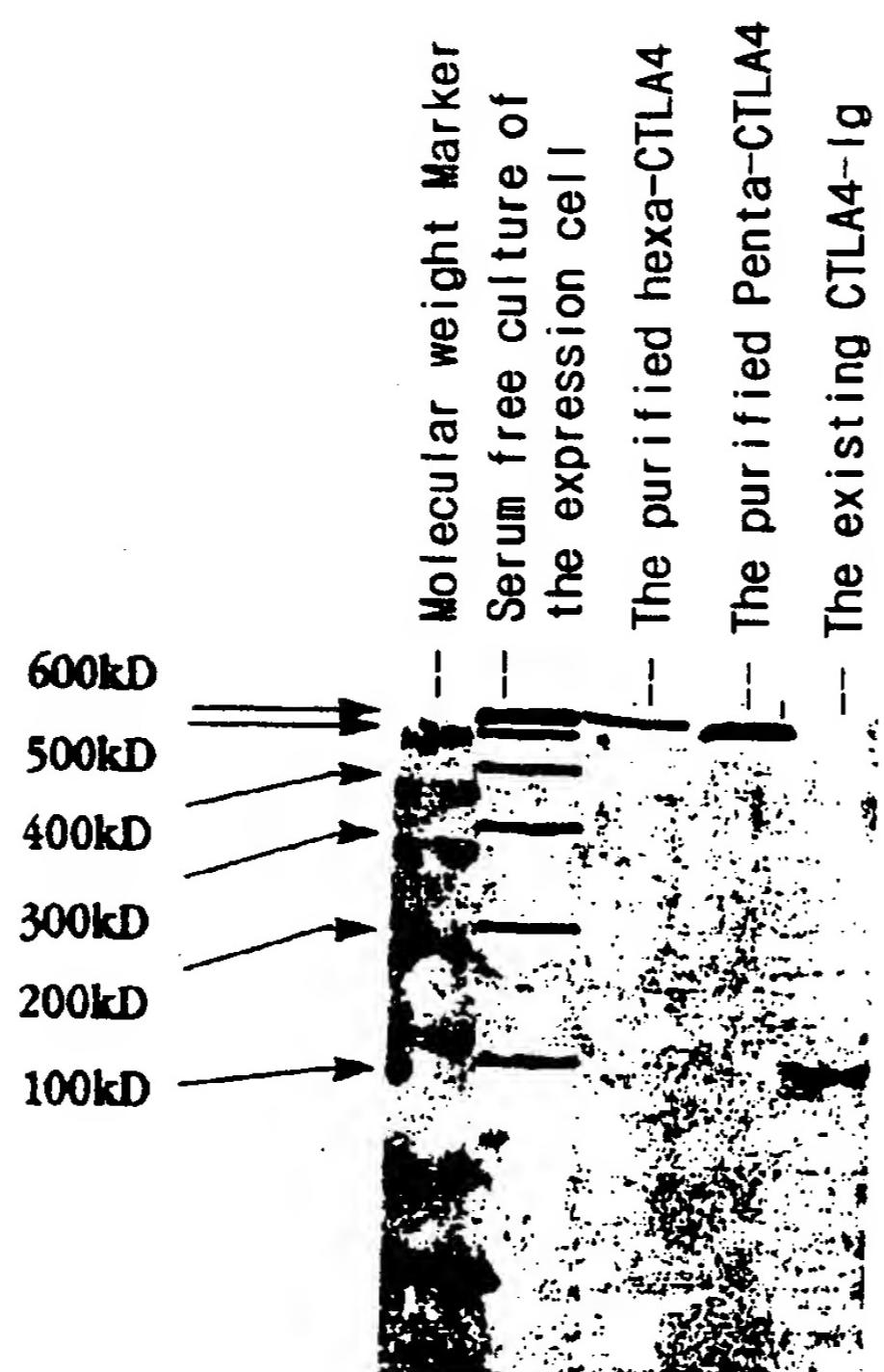
8/12

Fig. 5b



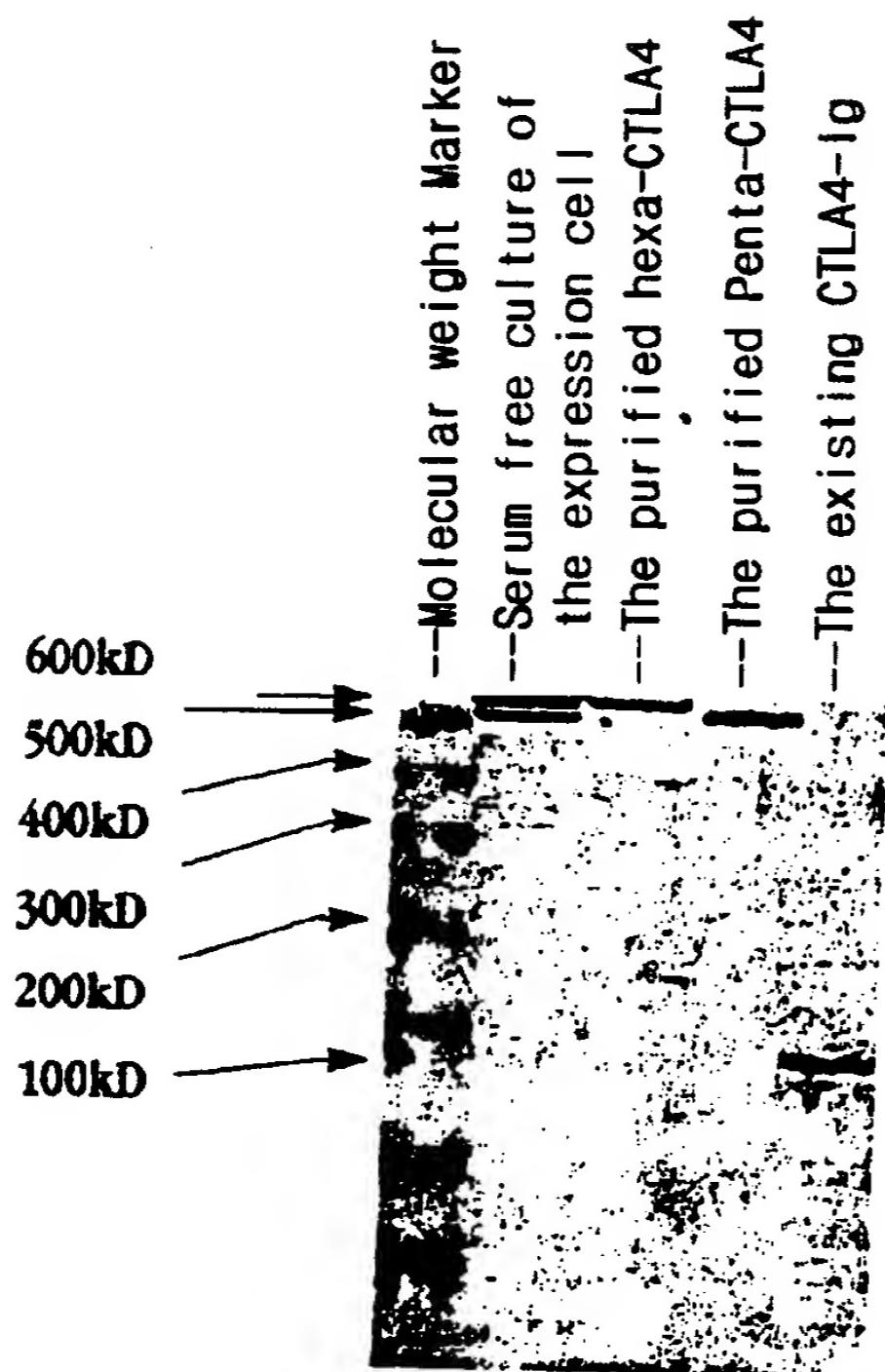
9/12

Fig. 6a

**A** The properties of the CTLA4-IgG<sub>1</sub>-Cys<sub>308</sub> fusion protein

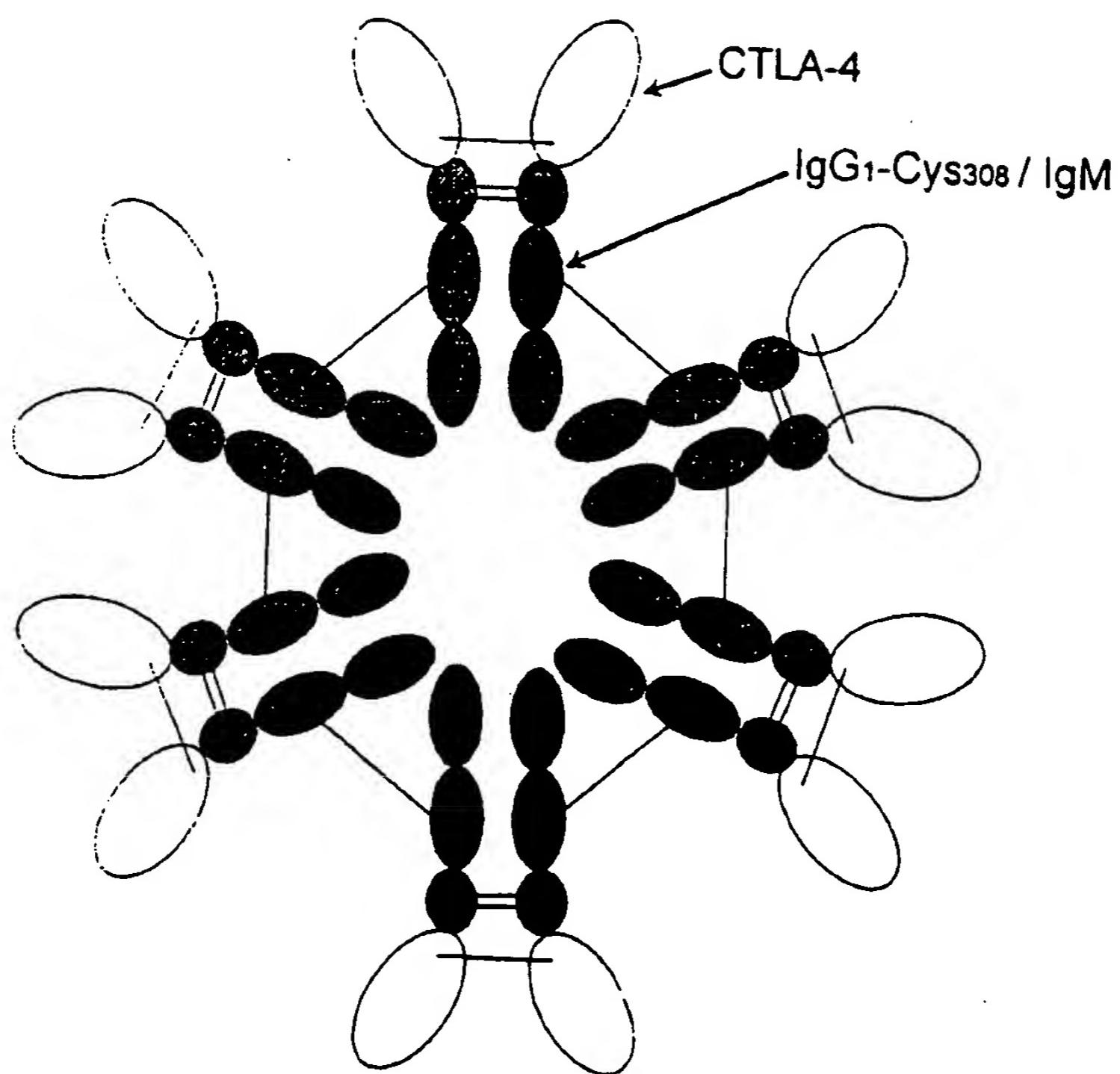
10/12

Fig. 6b

**B** The properties of the CTLA4-IgM fusion protein

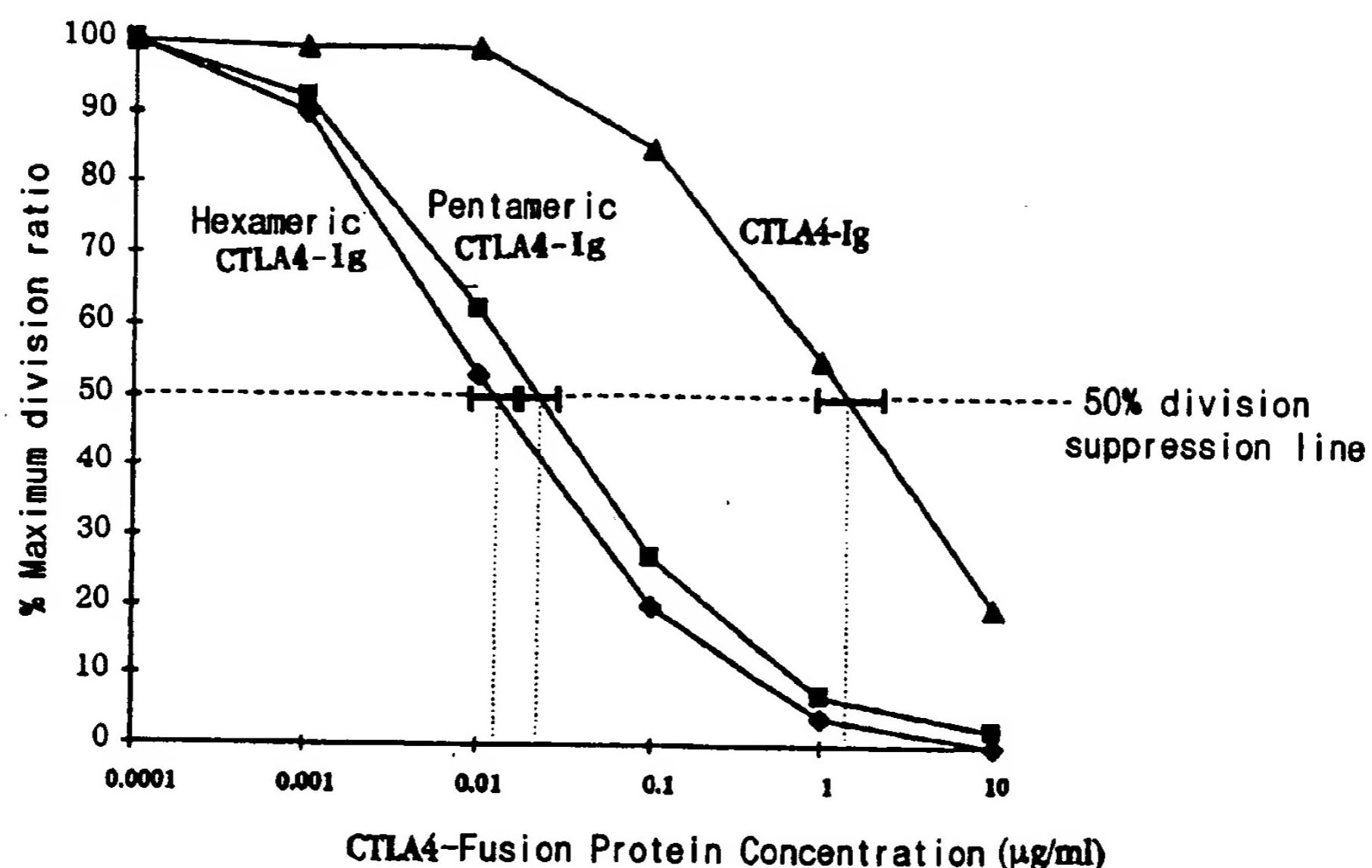
11/12

Fig. 7



12/12

Fig. 8



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR 98/00009

## A. CLASSIFICATION OF SUBJECT MATTER

IPC<sup>6</sup>: C 12 N 15/62; A 61 K 38/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC<sup>6</sup>: C 12 N 15/62; A 61 K 38/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPIL

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 682 039 A1 (BRISTOL-MYERS SQUIBB COMPANY) 15 November 1995 (15.11.95), abstract; claims 1,29.	1,6
A	US 5 434 131 A (LINSLEY et al.) 18 July 1995 (18.07.95), abstract; claims 5,6. ----	1,6

Further documents are listed in the continuation of Box C.

See patent family annex.

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Date of the actual completion of the international search

04 May 1998 (04.05.98)

Date of mailing of the international search report

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**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No.

PCT/KR 98/00009

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